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(54) Abstract Title
Drive circuit for electroluminescent display providing uniform brightness

(57) A drive circuit for an EL display device capable of permitting picture cells of an EL display device to have a substantially equal current density, to thereby exhibit uniform luminance sufficient to provide display of the display device with increased quality, even when the picture cells are different in area, luminous color and/or luminous efficiency from each other. A luminance correction data storage section is stored therein with correction data corresponding to areas of the picture cells. The correction data of each picture cell corresponding to display data are read from the luminance correction data storage section, so that a current flowed between two electrode groups of the EL display device may be variably controlled for every picture cell while rendering a period of time during which the current is flowed therebetween constant, based on the correction data read.

In an alternative embodiment, the time period of current flow is varied while the current flow remains constant.

FIG.3

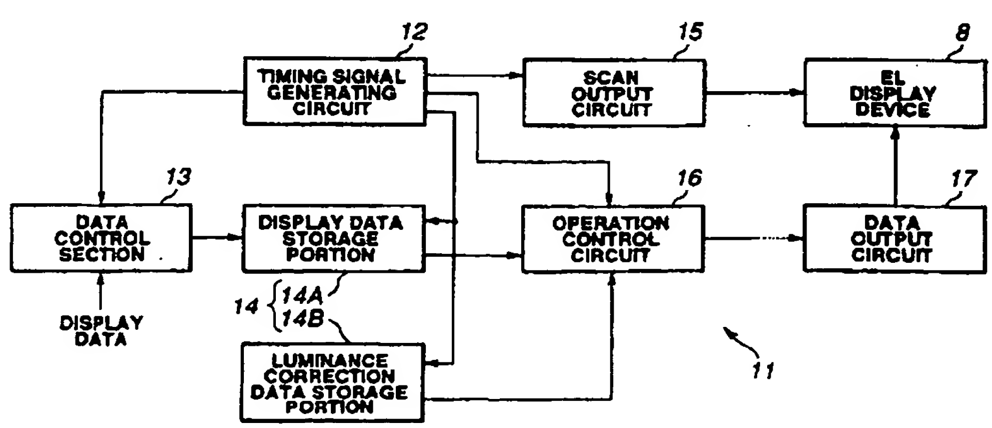

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FIG.1

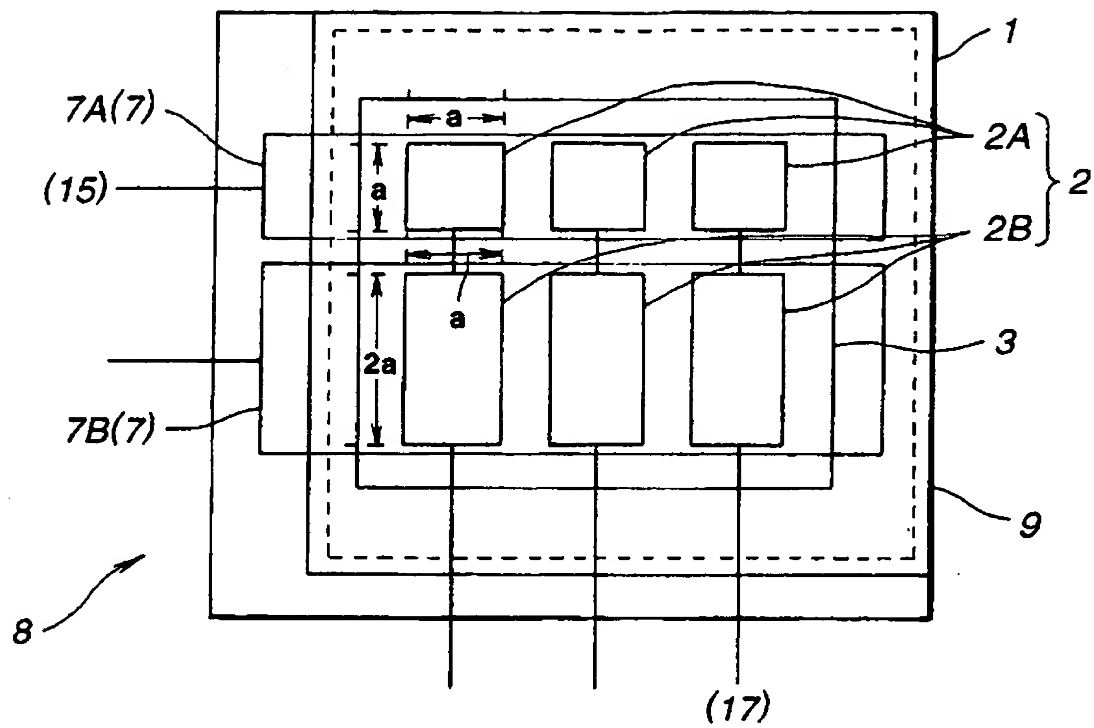
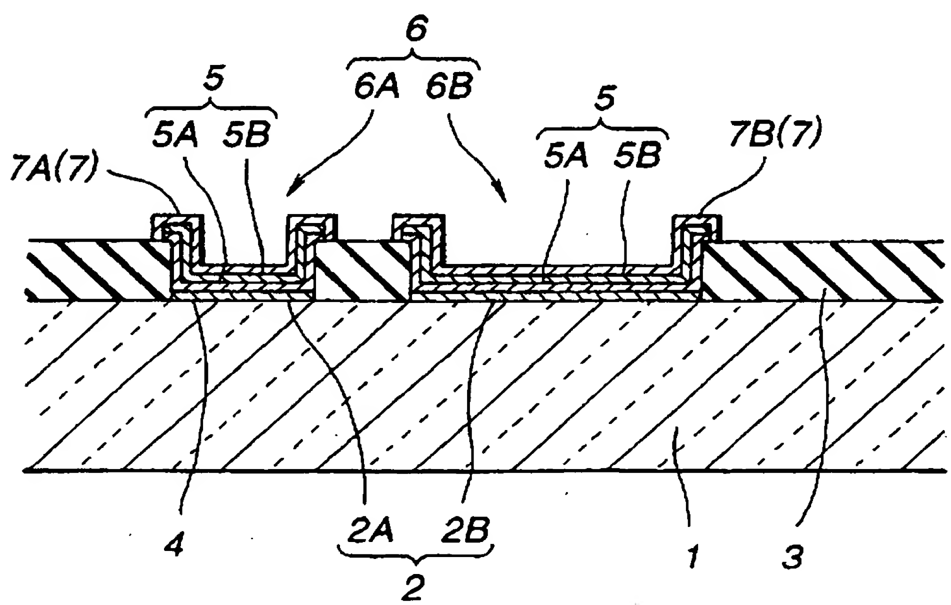
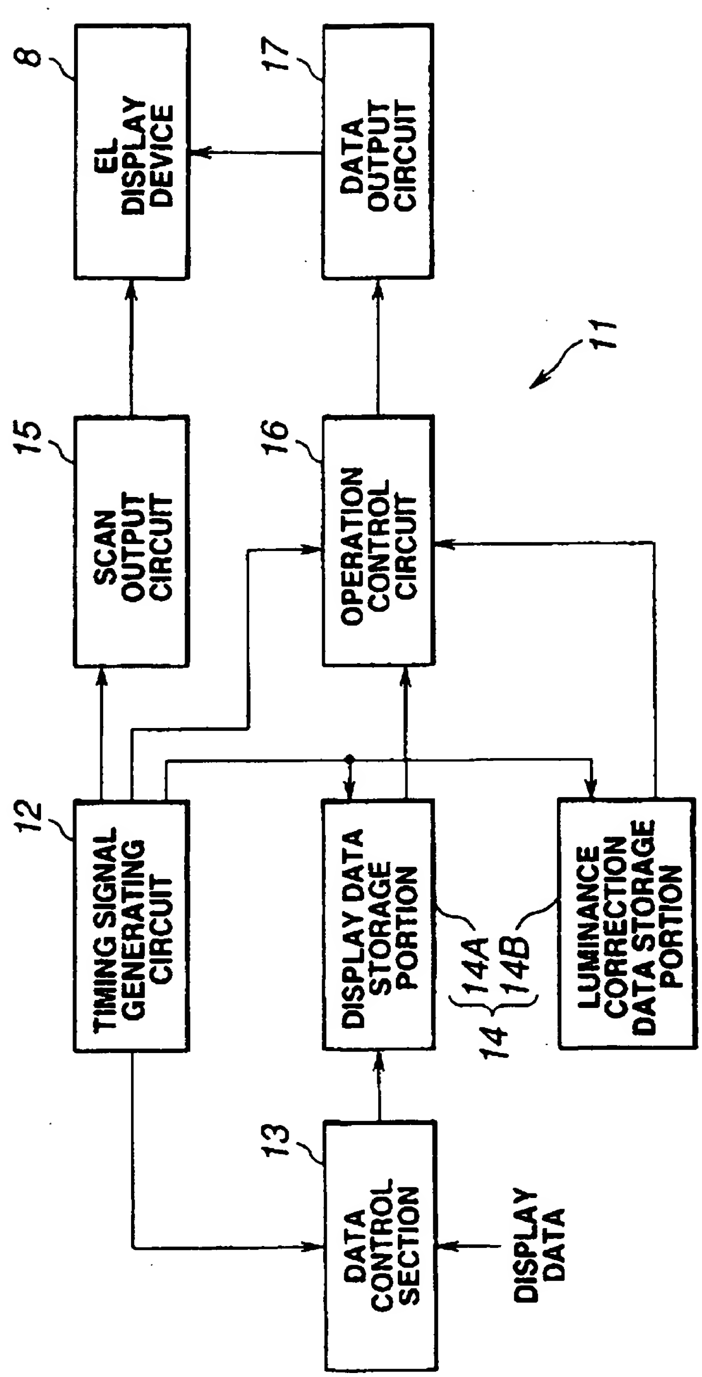

7A(7)
(15)
7B(7)
8
a
a
a
2a
1
2A
2
2B
3
9
(17)

FIG.2


6
6A 6B
5
5A 5B
5
5A 5B
7A(7)
7B(7)
4
2A 2B
2
1
3

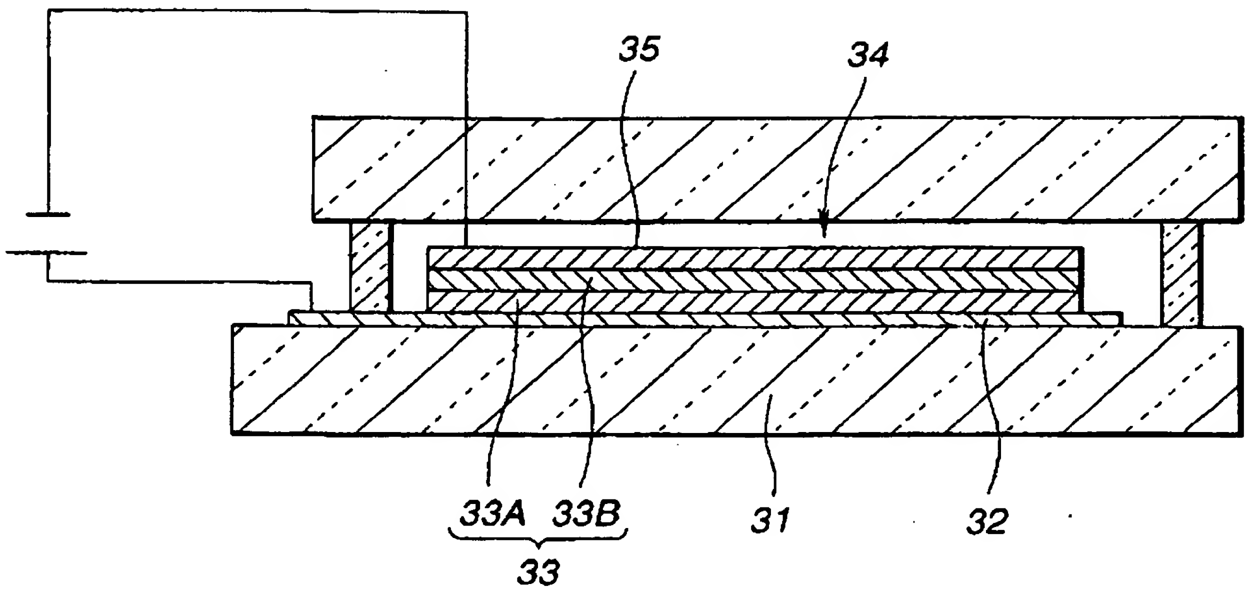
2|3

FIG.3


EL DISPLAY DEVICE
DATA OUTPUT CIRCUIT
SCAN OUTPUT CIRCUIT
OPERATION CONTROL CIRCUIT
TIMING SIGNAL GENERATING CIRCUIT
DISPLAY DATA STORAGE PORTION
LUMINANCE CORRECTION DATA STORAGE PORTION
DATA CONTROL SECTION
DISPLAY DATA
8
17
15
16
11
12
13
14
14A
14B

313

FIG.4



DRIVE CIRCUIT FOR ELECTROLUMINESCENT DISPLAY DEVICE

This invention relates to a drive circuit for an electroluminescent display device, and more particularly to a drive circuit for an electroluminescent display device wherein organic layers each made of an organic compound such as a hole transport layer, a luminous layer and the like are laminatedly arranged in a predetermined display pattern between a pair of electrode groups of which at least one is made of a transparent conductive layer.

An organic electroluminescent (hereinafter referred to as "EL") display device is constructed so as to interposedly arrange a thin film containing an organic compound between a cathode electrode and an anode electrode and inject electrons and positive holes into the thin film to recombine the electrons and positive holes with each other to produce excitons, resulting in light (fluorescence or luminescence) emitted from the excitons during deactivation thereof being utilized for display.

Now, a conventional EL display device in which such an organic EL device is incorporated will be described with reference to Fig. 4. The EL display device includes a glass substrate 31 made of an insulating and light-permeable glass material and a transparent electrode made of indium tin oxide (ITO) and formed on the glass substrate 31. The transparent electrode 32 is laminatedly formed thereon with an organic layer 33, which is formed of a thin film made of an organic phosphor. The organic layer 33 includes a hole transport layer 33A and a luminous layer 33B formed on the transparent electrode 32 in order, resulting in being constructed into a two-layer structure and providing each of picture cells 34. The luminous layer 33B has a metal electrode 35 laminated on the luminous layer 33B. The metal electrode 35 is made of metal such as Al, Ag, Mg:Ag, Al:Li or the like.

In the EL display device thus constructed, a voltage is applied between the transparent electrode 32 and the metal electrode 35 while acting the transparent electrode 32 as an anode electrode, resulting in a current of a constant level being

flowed therebetween. This permits electrons and positive holes to be injected into the organic layer 33 from the transparent electrode 32 and metal electrode 35, respectively. Then, the electrons and positive holes thus injected are recombined together to produce excitons, so that light emitted from the excitons during deactivation of the excitons may provide desired luminous display.

The EL display device is driven while constantly flowing a current of a constant level to each of the picture cells rather than according to voltage driving, to thereby exhibit uniform luminescence and compensate a change of the elements with time.

However, when the EL display device is constructed so as to carry out display by a combination of picture cells different in area, constant-current driving causes luminance of the display to be inversely proportional to a luminous area, resulting in failing to permit the EL display device to exhibit uniform luminance, leading to a deterioration in quality of display. A similar problem arises when the picture cells are different in luminous color or luminous efficiency from each other.

The present invention has been made in view of the foregoing disadvantage of the prior art.

Accordingly, it is an object of the present invention to provide a drive circuit for an EL display device which is capable of permitting picture cells to exhibit uniform luminance irrespective of a difference in area, luminous color and/or luminous efficiency between the picture cells.

It is another object of the present invention to provide a drive circuit for an EL display device which is capable of providing display with increased quality.

In accordance with the present invention, a drive circuit is provided for an EL display device which includes two electrode groups of which at least one is made of a light-permeable material and organic layers laminatedly arranged between the two electrode groups so as to provide picture cells different in area from each other acting as a luminous section, wherein a voltage is applied between the two electrode groups while acting one of the two electrode groups as an anode, to thereby permit a current

of a predetermined level to be flowed between the two electrode groups, resulting in the EL display device carrying out desired display. The drive circuit includes a luminance correction data storage section having correction data which correspond to areas of the picture cells stored therein. The correction data of each of the picture cells corresponding to display data are read from the luminance correction data storage section, so that the current flowed between the electrode groups is variably controlled for every picture cell while rendering a period of time during which the current is flowed between the electrode groups constant, based on the correction data read.

Also, in accordance with the present invention, a drive circuit is provided for an EL display device which includes two electrode groups of which at least one is made of a light-permeable material and organic layers laminatedly arranged between the two electrode groups so as to provide picture cells different in area from each other acting as a luminous section, wherein a voltage is applied between the two electrode groups while acting one of the two electrode groups as an anode, to thereby permit a current of a predetermined level to be flowed between the two electrode groups, resulting in the EL display device carrying out desired display. The drive circuit includes a luminance correction data storage section having correction data which correspond to areas of the picture cells stored therein. The correction data of each of the picture cells corresponding to display data are read from the luminance correction data storage section, so that a period of time during which the current is flowed between the electrode groups variably controlled for every picture cell while rendering a current flowed to each of the picture cells constant, based on the correction data read.

In a preferred embodiment of the present invention, the correction data depend on a luminous color of each of the picture cells. Alternatively, the correction data may depend on luminous efficiency of each of the picture cells.

These and other objects and many of the attendant advantages of the present invention will be readily appreciated

as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings; wherein:

Fig. 1 is a plan view showing an EL display device in which a drive circuit according to the present invention may be incorporated by way of example;

Fig. 2 is a fragmentary enlarged side elevation view in section of the EL display device shown in Fig. 1;

Fig. 3 is a block diagram showing an embodiment of a drive circuit for an EL display device according to the present invention; and

Fig. 4 is a sectional side elevation view schematically showing a conventional EL display device in which an organic EL display device is incorporated.

Now, a drive circuit for an EL display device according to the present invention will be described hereinafter with reference to the accompanying drawings.

Referring first to Fig. 1, an EL display device in which a drive circuit according to the present invention may be incorporated is illustrated by way of example. The EL display device includes an element substrate 1 of a rectangular shape acting as a base. The element substrate 1 is provided on a front surface thereof with a transparent electrode group 2, which is formed of a light-permeable material such as an ITO or the like into a substantially uniform thickness by etching, mask deposition or the like. In Fig. 1, the transparent electrode group 2 includes three transparent electrodes 2A arranged in a line on an upper row and three transparent electrodes 2B arranged in a line on a lower row, resulting in forming a 2-row and 3-column matrix. A part of each of the transparent electrodes 2A and 2B acts as a wiring, which is led out of each of the transparent electrodes 2A and 2B to an outside of the element substrate 1 and then connected to a data output circuit 17 of a drive circuit of the present invention described hereinafter.

The transparent electrode group 2, as shown in Figs. 1 and 2, is laminatedly provided thereon with an insulating layer 3 of an increased resistance, which is made of, for example, epoxy

resin, frit glass or an organic silica compound by calcination and formed into a rectangular shape. The insulating layer 3 is provided with through sections 4, each of which is formed by boring a part of the insulating layer 3 into a shape corresponding to each of the transparent electrodes 2A and 2B, resulting in being patterned.

The insulating layer 3 is formed into a substantially uniform thickness by printing, mask deposition, etching or the like. More specifically, it may be formed by boring SiN or SiO_2 in a desired pattern by etching. Alternatively, it may be formed either by printing frit glass or an organic silica compound in a desired pattern, followed by calcination or by patterning heat-resistant photosensitive resin in a predetermined configuration by photolithography.

The transparent electrodes 2A and 2B of the transparent electrode group 2, as shown in Fig. 2, each have an organic layer 5 laminatedly formed thereon so as to fill up each of the through sections 4 of the insulating layer 3. In Fig. 2, the organic layers 5 each are constructed into a two-layer structure including a hole transfer layer 5A made of an organic compound such as, for example, diamine or the like and a luminous layer 5B made of an organic compound, wherein the lamination is carried out in order of the hole transport layer 5A and luminous layer 5B.

The organic layers 5 each function at a portion thereof which fills up each of the through sections 4 of the insulating layer 3 as a picture cell 6 constituting a luminous section. In the illustrated embodiment, the picture cells 6 include three picture cells 6A arranged in a line on an upper row and three picture cells 6B arranged in a line on a lower row. The upper picture cells 6A each are formed into a square shape of a in length of one side and the lower picture cells 6B each are formed into a rectangular shape having an area twice as large as that of the upper picture cell 6A. Luminescence of the organic layers 5 permits display due to an array of the picture cells 6 to be observed through the element substrate 1.

The luminous layers 5B each may be made of a luminous material such as, for example, aluminum quinoline (Alq), distyryl

allylene or the like when it is constructed so as to emit light by itself. Alternatively, it may be constructed so as to emit light by doping the luminous layer 5B with another luminous substance (dopant) in a trace amount. In this instance, quinacridon (Qd), a pigment for laser or the like may be used as the dopant.

The luminous layers 5B, as shown in Fig. 1, each are laminatedly formed thereon with a metal electrode 7A or 7B so as to cover the picture cells 6A and 6B of each of two rows. . The metal electrodes 7A and 7B thus formed constitute a metal electrode group 7. The metal electrodes 7A and 7B each are formed of Al, Ag, Mg:Ag, Al:Li or the like into a substantially uniform thickness by etching, mask deposition or the like. The metal electrode group 7 is connected to a scan output circuit 15 of the drive circuit 11 described hereinafter.

The element substrate 1 has a sealing substrate 9 fixed on an outer peripheral portion thereof so as to act as a sealing member. Such fixing of the sealing substrate 9 on the element substrate 1 is carried out in an atmosphere from which water is removed to the utmost such as a dry inert gas atmosphere, a dry air atmosphere or the like. Nitrogen may be used as the inert gas. Such arrangement of the sealing substrate 9 ensures protection of the transparent electrode group 2, metal electrode group 7 and organic layers 5 and provides the organic EL display device with high definition.

In the EL display device of the illustrated embodiment, the transparent electrode group 2 and metal electrode group 7 are arranged in a manner contrary to that described above. In this instance, the element substrate 1 is not necessarily required to be transparent, therefore, it may be made of glass exhibiting insulating properties. Also, in the illustrated embodiment, it is merely required that at least one of the transparent electrode group 2 and metal electrode 7 is made of a light-permeable material.

The EL display device of the illustrated embodiment thus constructed is operated in such a manner that a voltage is applied between each of the transparent electrodes 2A and 2B and each of the metal electrodes 7a and 7B while acting one of the

electrode groups 2 and 7 as an anode, to thereby permit a current of a constant level to be flowed between the transparent electrode group 2 and the metal electrode group 7, resulting in providing desired display. The anode may be constituted by, for example, the transparent electrode group 7.

The drive circuit 11 for driving the thus-constructed EL display device by means of a constant current, as shown in Fig. 3, generally includes a timing signal generating circuit 12, a data control section 13, a storage section 14 including a display data storage portion 14A and a luminance correction data storage portion 14B, the scan output circuit 15 briefly described above, an operation control circuit 16, and the data output circuit 17 briefly described above.

The timing signal generating circuit 12 functions to successively select and scan the metal electrodes 7A and 7B for every row and input a data signal to the transparent electrode group, so that desired display may be carried out. For this purpose, the timing signal generating circuit 12 outputs a predetermined timing signal to each of the data control section 13, storage section 14, scan output circuit 15 and operation control circuit 16.

The data control section 13 functions to time-sequentially take in display data successively inputted thereto by means of the timing signal outputted from the timing signal generating circuit and then store the display data in the display data storage portion 14A. In Fig. 1, the display data are data for displaying, for example, alphabetical characters "T", "I", "L" and the like.

The luminance correction data storage portion 14B has luminance correction data which correspond to an area of each of the picture cells 6 stored therein in the form of a table. More particularly, a level of a voltage to be applied to a picture cell of a predetermined area is previously set to be reference data and correction data depending on a voltage level corresponding to an area of each of the picture cells 6 are stored in the form of a table based on the reference data.

Alternatively, a pulse width of a voltage to be applied to a picture cell of a predetermined area is previously set to be

reference data and correction data depending on a voltage level corresponding to an area of each of the picture cells 6 are stored in the form of a table based on reference data.

The scan output circuit 15 functions to successively select and scan the metal electrodes 7A and 7B of the EL display device for every row by means of the timing signal outputted from the timing signal generating circuit 12. In the EL display device shown in Fig. 1, the selection and scanning are carried out in order of the three metal electrodes 7A on the upper row and the three metal electrodes 7B on the lower row.

The operation control circuit 16 functions to read, from the luminance correction data storage portion 14B, correction data for every picture cell corresponding to display data read from the display data storage portion 14A by means of the timing signal outputted from the timing signal generating circuit 12.

In this instance, when a construction wherein the luminance correction data storage portion 14B has correction data based on a voltage level stored therein is employed, a level of a voltage inputted to a driver circuit of the data output circuit 17 is varied by the correction data read, so that an output current flowed between the transparent electrode group 2 and the metal electrode group 7 may be varied depending on an area of each of the picture cells 6. At this time, a period of time during which the current is flowed therebetween is kept constant. For example, supposing that an output current at the time when a voltage level of the correction data inputted for driving the picture cells 6A for luminescence is set to be reference data is 5 mA/cm^2, a voltage of a level twice as high as that of the reference data is inputted to the data output circuit 17, resulting in an output current thereof being 10 mA/cm^2.

On the contrary, when a construction wherein the luminance correction data storage portion 14B has correction data based on a pulse width stored therein is employed, a pulse width of a voltage inputted to the driver circuit of the data output circuit 17 is varied by the correction data read, so that a period of time during which an output current is flowed between each of the transparent electrodes 2A and 2B and each of the metal electrodes 7A and 7B may be varied. For example, supposing

that an output current at the time when a pulse width of the correction data inputted for driving the picture cells 6A for luminescence is set to be reference data is 5 mA/cm², a voltage of a pulse width twice as large as that of the reference data is inputted to the data output circuit 17, resulting in an output current thereof being 10 mA/cm².

The data output circuit 17 functions to output a data signal for on-off operation of each of the picture cells 6 in synchronism with the scan output circuit 15. More specifically, the data output circuit 17 is constituted of a driver circuit including transistors of the constant-current drive type corresponding in number to the transparent electrodes 2A and 2B of the transparent electrode group 2. The data output circuit 17, as described above, is so constructed that an input voltage thereof is controlled so as to provide an output current corresponding to the correction data from the operation control circuit 16, resulting in a current of a level depending on the area of the picture cell being flowed between each of the transparent electrodes 2A and 2B and each of the metal electrodes 7A and 7B.

Thus, the EL display device of the illustrated embodiment, even when the luminous section is constituted of the picture cells different in area, permits the picture cells 6 to have the same average current density, resulting in the picture cells exhibiting uniform luminance, so that the EL display device may provide display with increased quality.

In the illustrated embodiment, the organic layers 5 each are constructed into the two-layer structure including the hole transport layer 5A and luminous layer 5B. Alternatively, the organic layer 5 may be constituted by a combination of the luminous layer and a charge transport layer such as a positive transport layer, a hole injection/transport layer, an electron injection layer, an electron injection/transport layer or the like. Alternatively, it may be constructed into a single-layer structure including only the luminous layer, a two-layer structure including the luminous layer and hole transport layer or the luminous layer and electron injection layer, a three-layer structure including the hole transport, luminous layer and

electron injection layer, or the like.

The electron injection layer may be made of elemental metal reduced in work function such as, for example, Li, Na, Mg, Ca or the like or alloy reduced in work function such as, for example, Al:Li, Mg:In, Mg:Ag or the like, to thereby facilitate injection of electrons thereinto.

A pattern of the picture cells 6 incorporated in the EL display device is not limited to that described above. It may be determined as desired depending on a configuration of the picture cells 6, an area thereof and the number thereof.

In the EL display device described above, the picture cells 6 includes the picture cells 6A and picture cells 6B different in area from each other. Alternatively, the picture cells may include picture cells different in luminous color and/or luminous efficiency from each other. In this instance, the luminance correction data storage portion 14B has luminance correction data for every luminous color or luminous efficiency of each of the picture cells 6 stored therein in the form of a table for every picture cell.

More particularly, the luminance correction data storage portion 14B is stored therein with a level or pulse width of a voltage to be applied for every luminous color or luminous efficiency of each of the picture cells 6 in the form of correction data. Correction data corresponding to display data permit an output of the data output circuit 17 to be controlled so as to provide a current density corresponding to required luminance of each of the picture cells 6 as in the above-described luminescence of the picture cells 6A and 6B different in area from each other. This permits a current of a constant level determined depending on the required luminance to be fed between each of the transparent electrodes 2A and 2B and each of the metal electrodes 7A and 7B.

Alternatively, the luminance correction data storage portion 14B is stored therein with a level or pulse width of a voltage to be applied for every area, luminous color or luminous efficiency of each of the picture cells 6 as correction data in the form of a table for every picture cell, so that correction data corresponding to display data permit an output of the data

output circuit 17 to be controlled. The correction data may be in the form of a level or pulse width of a voltage corresponding to any combination of an area of each of the picture cells 6, a luminous color thereof and luminous efficiency thereof.

As can be seen from the foregoing, the present invention, even when the picture cells are different in area, luminous color and/or luminous efficiency from each other, permits the picture cells to have a substantially equal current density, resulting in the picture cells exhibiting uniform luminance, so that the display may be provided with increased quality.

Claims:

1. A drive circuit for an EL display device which includes two electrode groups of which at least one is made of a light-permeable material and organic layers laminatedly arranged between the two electrode groups so as to provide picture cells different in area from each other acting as a luminous section, wherein a voltage is applied thereto while acting one of the two electrode groups as an anode, to thereby permit a current of a predetermined level to be flowed between the two electrode groups, resulting in the EL display device carrying out desired display, comprising:

a luminance correction data storage section having correction data which correspond to areas of said picture cells stored therein;

whereby the correction data of each of said picture cells corresponding to display data are read from said luminance correction data storage section, so that the current flowed between said electrode groups is variably controlled for every picture cell while rendering a period of time during which the current is flowed between said electrode groups constant, based on the correction data read.

2. A drive circuit as defined in claim 1, wherein said correction data depend on a luminous color of each of said picture cells.

3. A drive circuit as defined in claim 1, wherein said correction data depend on luminous efficiency of each of said picture cells.

4. A drive circuit for an EL display device which includes two electrode groups of which at least one is made of a light-permeable material and organic layers laminatedly arranged between the two electrode groups so as to provide picture cells different in area from each other acting as a luminous section, wherein a voltage is applied thereto while acting one of the two electrode groups as an anode, to thereby permit a current of a predetermined level to be flowed between the two electrode groups, resulting in the EL display device carrying out desired display, comprising:

a luminance correction data storage section having

correction data which correspond to areas of said picture cells stored therein;

whereby the correction data of each of said picture cells corresponding to display data are read from said luminance correction data storage section, so that a period of time during which the current is flowed between said electrode groups variably controlled for every picture cell while rendering a current flowed to each of said picture cells constant, based on the correction data read.

5. A drive circuit as defined in claim 1, wherein said correction data depend on a luminous color of each of said picture cells.

6. A drive circuit as defined in claim 1, wherein said correction data depend on luminous efficiency of each of said picture cells.